"Towards consistent uncertainty management in LCA

Consensus building and guideline development for handling uncertainty in LCA"

Wednesday, September 30, 1pm-7pm

UNEP-SETAC working group on uncertainty management in LCA

What: Facilitate management of uncertainty in all stages of an LCA study, thus increasing its quality, through:

- Establishment of recommended practice for uncertainty management in LCA;
- Elaboration of guidance for **practitioners** and method **developers** on:
  - Which types of uncertainty to consider,
  - What important/dominant sources of uncertainty in LCA are,
  - How to estimate them quantitatively,
  - How to communicate them effectively to decision-makers,
  - How to interpret them for decision-making;
- Development of a practical framework based on a tired approach starting from uncertainty screening to full assessment;

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What: Facilitate management of uncertainty in all stages of an LCA study, thus increasing its quality, through:

- Consideration of all uncertainty types (parameter, model, scenario, etc.) as far as possible, including guidance on unquantifiable uncertainty (awareness);
- Addressing strategies for uncertainty reduction by focusing on major sources of uncertainty;
- A series of workshops to promote consensus building and gather relevant inputs;
- Development of relevant course material and teaching of courses on the subject (capacity building);
- Creation of a repository of information and a method library (web-based wiki) critically describing existing approaches (depending on funding);

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Who:

- Ralph K. Rosenbaum – Chair (CIRAIG, Montreal, Canada)
- Andreas Ciroth – Co-chair (GreenDeltaTC, Berlin, Germany)
- Tom McKone (UC Berkeley/LBNL, Berkeley, USA)
- Jinglan Hong (Shandong University, Jinnan, China)
- Olivier Jolliet (University of Michigan, USA)
- Reinout Heijungs (Leiden University, The Netherlands)
- Fausto Freire (University of Coimbra, Portugal)
- Manfred Lenzen (University of Sydney, Australia)
- Mark Huijbregts (Radboud University Nijmegen, Netherlands)
- Rolf Frischknecht (ESU-Services, Zurich, Switzerland)

Objective and scope of the workshop series

- Open workshops inviting interested parties and stakeholders in
  - November 2008 in Tampa, FL, USA;
  - September 2009 in Boston, MA, USA.
- Basis for a ***stakeholder-consensus-building-process*** feeding into guidelines on how to ***operationalise*** and implement ***consistent uncertainty management*** in daily LCA practice;
- Seek input from various perspectives ranging from a user/practitioner's point of view to experts' insights and all kinds of related and relevant experiences.

Workshop agenda

- 1:00pm – 1:20pm “Introduction, context, background”
- 1:20pm – 1:40pm “Draft framework and guidelines”
- 1:40pm – 3:00pm Discussion
- 3:00pm – 3:20pm Break
- 3:30pm – 5:00pm Discussion
- 5:00pm – 5:20pm Break
- 5:20pm – 7:00pm Discussion, wrap up and adjourn workshop
- 7:00pm Informal dinner together

Objective and scope of the workshop series

Objective:

Expose and discuss a first draft of an LCA uncertainty management framework and guidance based on the results of the uncertainty working group and the first LCA uncertainty management workshop.

Objective and scope of the workshop series

Workshop questions:

- Can the framework help operationalising and guiding uncertainty management in LCA?
- How can the framework be improved?
- What are rules and principles for good practice?
- What do we need to cover, what guidance/information would users expect?

Workshop subjects

Guidelines on:

- Types of uncertainty occurring in LCA, their sources and how to characterize them (combined in the framework)
- Interpretation of uncertainty in LCA
- Communication of uncertainty
- Matching uncertainty characterization to management decisions

Types of uncertainty in LCA and possible sources

Type	LCA phase				
	Goal and scope	Inventory	Choice of impact categories and classification	Characterization	Weighting and normalization
Data uncertainty		Inaccurate or no input flows and emission factors		Uncertainty in lifetimes of substances	Inaccurate normalization data
Model Uncertainty		Linear instead of non-linear modeling	Impact categories are not known; Contribution of impact category is not known	Characterization factors are not known	Weighing criteria are not operational
Uncertainty due to choices	Choice of functional unit, system boundaries	Choice of allocation methods, technology level	Leaving out known impact categories	Choice of the characterization method(s)	
Temporal variability		Differences in yearly emission factors		Change of temperature over time	
Spatial variability		Regional differences in emissions factors		Regional differences in environmental sensitivity	
Variability between objects/ sources		Differences in technology between factories which produce the same product		Differences in human exposure patterns	
Mistakes	Any	Any	Any	Any	Any

Sources of uncertainty in LCA and their quantification

Source of uncertainty	Description	Examples on how they affect an LCA	How to quantify it
Choice of functional unit	Typically there are several ways of defining a functional unit which may vary by value choices (e.g. quantities, durations,...), description choices (e.g. biofuels as a commodity/product: 1l E85, or as a service: 1km driven in a bus), etc..	When defining the functional unit of biofuels as a service, the vehicle needs to be included which is not needed when defining them as a product.	1) Testing the sensitivity of the result (or the scenario ranking) to the functional unit. 2) A part of the uncertainty in the choice of the functional unit will not be quantifiable, but should still be reported.
Inaccurate or no input flows and emission factors			
Temporal variability of emissions	Reported emissions might vary depending on their reference year.	The choice of a single value for one reference year limits the representativeness of an LCA, even more so if the reference year is not the same throughout the whole study.	Calculate an average and its standard deviation for all available values, or a weighted average in case some values are more representative in the context of the study than others, e.g. constant increase/decrease of emissions over time. Some values might be excluded for non-representativeness, e.g. before/after installing a filter.
Spatial variability of emissions			
Regional, spatial and population variability of fate factors			
Regional, spatial and population variability of fate factors			
Variation in susceptibility among different populations and/or among different regions			

Tiered framework

Tier 0:

- Clear definition of what is considered a significant difference between scenarios for each impact category;
- so that results can be analysed with respect to these.

Tiered framework

Tier 1:

- Screening level approaches providing information on importance/sensitivity of parameters, choices, assumptions, etc. within a study focusing on parameter uncertainty (e.g. sensitivity or importance analysis);
- helps identifying and hence focusing on important sources of uncertainty which can then be further quantified and eventually reduced where possible.

Tiered framework

Tier 2:

- Qualitative and semi-quantitative uncertainty assessment;
- with systematic identification and classification/ characterization of uncertainties for all parameters, choices, and assumptions above a certain importance or sensitivity threshold including parameter and scenario uncertainty;
- e.g. pedigree matrix in ecoinvent;
- propagation via analytical estimation methods such as Taylor series expansion;
- Will provide a first estimate of output distributions and confidence factors.

Tiered framework

Tier 3:

- Quantitative uncertainty assessment;
- with systematic quantification of uncertainties and variability for all parameters/choices/assumptions above a certain importance/influence or sensitivity threshold accounting for all quantifiable uncertainties;
- using actual observed distribution types, standard deviations/residual errors etc.;
- propagation via probabilistic (Monte Carlo simulation) or analytical (Taylor series expansion) methods.
- Will deliver refined information on the distribution type/shape and the variance of an output/result.

Tiered framework

Ideal (Tier 4):

- Detailed probabilistic uncertainty assessment;
- representing all relevant sources of influence by fully characterised uncertainty and variability separately;
- propagation using multidimensional probabilistic methods (e.g. 2-dimensional Monte Carlo simulation).
- This is the maximum precision level for an uncertainty assessment.

Tiered framework

Tier	0	1	2	3	Ideal (4)
Types of uncertainty captured	overall evaluation	none	parameter, choices	parameter, model, scenario	parameter, model, scenario
Variability captured	none	none	temporal, spatial	temporal, spatial	temporal, spatial, separately from uncertainty
Inputs required	expert judgement	none	classification of parameters and choices into discrete certainty classes	observed mean (geom., arithm. etc.), distribution type, standard deviation	observed distributions for variation and uncertainty separately
Propagation method	None	n/a (algorithms such as Fourier Amplitude Sensitivity Test (FAST) might be employed)	Taylor series expansion	Taylor series expansion, Monte Carlo simulation	Taylor series expansion, Monte Carlo simulation
Result(s) generated	evaluation of LCIA results against typical minimum variations	importance ranking based on sensitivity of a parameter on the result	uncertainty estimate (mean, standard deviation) with a fixed (hypothetical) distribution type, confidence in the result	uncertainty distribution (mean, standard deviation, distribution type) for each result (e.g. impact score), confidence in the result	uncertainty distribution (mean, standard deviation, distribution type) for each result (e.g. impact score), confidence in the result

Interpretation of uncertainty in LCA

- Scenario-comparison issues:
  - One can not compare two separately calculated scenarios.
  - Which metrics could be the basis for the comparison (probability to be wrong, etc.) → Confidence in the decision or how sure am I not to be wrong?
  - How to avoid people inflating or deflating uncertainty to show there is no difference between various scenarios by excessively overlapping scenarios?
  - When exactly is an option statistically preferable over others and when is no distinction possible?
- How to not discredit your study by showing its uncertainty?
- Outputs (single-scenario, multi-scenario, parametric, non-parametric)
- Use and misuse of data
- When do decision rule and scenario uncertainties dominate overall uncertainty?

Communication of uncertainty

- How many significant digits as a general rule?
- Issue with linguistic imprecision (e.g. choosing the wrong substance/process due to similar/close names as references/links not using CAS numbers, unit conversions e.g. tons/metric tons).
- Communicate which types of uncertainty have not been covered.
- What are good ways to aggregate and present the numerous uncertainty information that might be generated by an LCA study?
- Use of narratives.

Matching uncertainty characterization to management decisions

- What is the LCA decision and how will an LCIA and associated uncertainty characterization impact this decision?
- What level of detail will be useful to the decision maker?
- What level of detail will overwhelm and/or confuse the decision maker?
- When is sensitivity analysis more informative than probabilistic methods?
- Are there times when a narrative characterization of uncertainty is more informative than a quantitative characterization?
- How do we address the concern that uncertainty analysis will derail the LCA?